

Culvert Treatments

Design Manual

Chapter 8

Safety Design

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Culvert openings alongside the roadway should be analyzed to determine the best way to protect motorists that may run off the road. Smaller culvert openings can snag a wheel, causing a vehicle to lose control. Larger structures, such as box culverts, are a concern because of direct impacts, snagging, and drop-offs. It is therefore important to treat culverts in some manner to minimize risk for a motorist that has left the roadway. This section describes these treatments, including barrier design guidelines for when culverts need to be shielded. For more information on the treatment of culverts and other drainage structures, see Chapter 3 of the *AASHTO Roadside Design Guide*.

Culvert Guidelines

New and Reconstructed Highways

Except within medians, all pipe and box culverts, regardless of size, are extended to the clear zone. Even 18 and 24-inch (450 and 600 millimeter) diameter pipes are extended due to the enlarged opening created by the apron.

On divided highways, pipe culverts ≤ 36 inches (900 millimeters) in diameter are extended only to the normal foreslope on the median side. A pipe apron guard is installed on these pipes on the median side only.

Since culverts are extended to the clear zone or else made traversable with an apron guard, shielding with guardrail is normally not necessary on new and reconstructed highways.

3R Projects

Many culvert situations on 3R projects will have to be evaluated on a case-by-case basis. However, the following guidelines may be helpful to maintain a degree of consistency.

On freeways and expressways:

- box culverts and pipes > 36 inches (900 millimeters) in diameter are often extended to the clear zone or shielded.
- smaller pipe culverts are usually extended flush with the existing foreslope.

On other highways on the National Highway System (NHS):

- box culverts ≥ 6 feet (1.8 meters) across and pipes ≥ 6 feet (1800 millimeters) in diameter are often extended to the clear zone or shielded. Minor right-of-way may be acquired if needed.
- smaller pipe and box culverts are usually extended flush with the existing foreslope, if they can be extended with pre-cast pipe sections. Some odd-shaped box culverts may not fit any pre-cast sizes or shapes and are therefore extended in-kind, usually to the clear zone.

For non-NHS highways:

- normally, box culverts ≥ 6 feet (1.8 meters) across and pipes ≥ 6 feet (1800 millimeters) in diameter are used as constructed. Shielding or extending a large culvert is considered if accident history and/or a benefit/cost analysis indicate that treatment is warranted.
- smaller pipe and box culverts are usually extended flush with the existing foreslope, if they can be extended with pre-cast pipe sections.
- Right-of-way is normally not acquired for extending culverts on the non-NHS.

Grading and Culvert Extensions

Before shielding a culvert with barrier, other treatment options should be considered. These options include making the culvert traversable, extending the culvert beyond the clear zone, and eliminating the opening by connecting multiple culverts (sometimes feasible at interchanges or in the median).

Culvert openings should, in most cases, be made flush with the embankments from which they emerge. Protrusions of the culvert's headwall and the adjoining wingwalls should not be more than 4 inches (100 millimeters) above the terrain.

For larger culverts perpendicular to the roadway, it is preferable to extend them so their openings are outside the clear zone. For more information on applying the clear-zone concept, see Section 1C-2 of this manual and Chapter 3 of the AASHTO *Roadside Design Guide*. The designer should also flatten and extend the foreslope to cover the culvert, as shown on Typical 4304 or 4311.

Extending the culvert reduces the chance that a driver will collide with the opening, and it normally does not interfere with the culvert's hydraulic function. However, in some cases, extending a culvert may not be practical due to economic considerations or right-of-way limitations. In such cases, other alternatives must be considered.

Guardrail



Before shielding a culvert with guardrail, first determine if extending the culvert outside the clear zone is feasible.

Barrier design for culverts is the same as side obstacles (see Section 8B-1), except for the following exceptions:

- Concrete barrier is not used to shield culverts. If the distance from the edge of the design shoulder to the face of the obstacle is 14 feet (4.2 meters) or more, cable guardrail (RE-29C) may be used. If the distance from the edge of the design shoulder to the face of the obstacle is less than 14 feet (4.2 meters), w-beam guardrail with 6'-3" post spacing (RE-54A or RE-55A) should be used.
- The task of locating the installation line for culverts is the same as for side obstacles until the installation line is at the edge of the shoulder and the headwall of the culvert is less than 3.6 feet (1.0 meters) from the installation line. If the culvert is in this region (very close to the shoulder), the installation line should be placed so that there is 6 inches (150 millimeters) between the back of the posts and the headwall.

Low Fill Situations

Posts are required to be embedded 3 feet (1 meter) into the ground. However, getting 3 feet (1 meter) of post embedment occasionally is not possible because of a low-fill situation over the culvert. Two different options exist for this condition:

- W-beam guardrail can be nested together and the posts over the culvert can be eliminated as shown on Standard Road Plan RE-66C (“nesting” is the practice of bolting two pieces of guardrail together to the same posts—one on top of the other). Spans of 25 feet (7.62 meters) can be achieved with this method.¹
- Standard Road Plan RE-37 can be used. Post embedment is not a factor with this method because steel posts are bolted directly to the top of the culvert.

The RE-66C is the preferred option, as long as the culvert is narrow enough to fit between the remaining posts (24'-4" or 7.4 meters)—taking into account the skew of the culvert. For culverts wider than 24'-4" (7.4 meters), the RE-37 method must be used.

Tabulation

Tabulation 108-8B is used when shielding culverts with guardrail.

See Section 8B-10 for more information on tabulating guardrail.

Safety Grates

From a safety standpoint, the use of safety grates to make a culvert traversable is a desirable alternative. Safety grates should never be installed on the outlet of a culvert unless the inlet has been similarly protected.

Detail Sheet 540-4A

Detail Sheet 540-4A is used with box culverts that are perpendicular to the roadway. When using this design, the following guidelines apply:

- Grate bar spacing will be a minimum of 24 inches (600 millimeters) and a maximum of 30 inches (750 millimeters). The grate bars should be equally spaced along the cross bar.
- Guardrail or other treatment should be considered when the vertical drop (J) at the end of the sidewalls is greater than 2 feet (0.6 meters). See “Details of Dimensions” on Detail Sheet 540-4A for the definition of “J.”
- Grate bar and cross bar sizes depend upon the unsupported span of the member. Grate and cross bar size requirements are shown on Detail Sheet 540-4A. Do not exceed these span lengths. If longer bars are required, consult the Methods Section. Also, note that the crossbar diameter must be greater than or equal to the grate-bar diameter.
- Avoid midspan vertical supports if possible. If midspan supports are required, consult the Methods Section for assistance.
- “Details of Dimensions” on Detail Sheet 540-4A show the structure dimensions that need to be obtained from the original culvert plans.
- The culvert’s skew angle is defined as shown on Detail Sheet 540-4A.
- Use Tabulation 108-24.

¹ Rohde, Sicking, Beilenberg, Faller, Keller, and Polivka, “Development of a 7.62-m Long Span Guardrail System—Phase II,” MwRSF Research Report No. TRP-03-88-99.

Pipe-Apron Guards

In addition to culverts in the median as discussed on page 1, pipe apron guards may be useful in other situations. Standard Road Plan RF-26 provides construction details for pipe apron guards.

In urban areas, a pipe-apron guard should normally be used on the inlets of all pipe culverts ≤ 36 inches (900 millimeters) in diameter. The pipe-apron guard keeps children from playing in a culvert and can prevent persons from being pulled into the culvert during flooding. Pipe-apron guards should not be used on pipes greater than 36 inches (900 millimeters) in diameter. If an apron guard is desired on a pipe larger than 36 inches (900 millimeters) in diameter, consult the Preliminary Bridge Engineer and the Methods Section in the Office of Design.

A pipe-apron guard can also prevent debris from entering the culvert. Thus, it should also be considered for long crossroad culverts, particularly if they have bends.